

REMARKS35 U.S.C. 103 Rejections

Claims 1, 3-5, 12-35, and 42-60 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al., U.S. Patent No. 5,926,726 (hereinafter "Bour") in view of Koike et al., U.S. Patent No. 5,811,319 (hereinafter "Koike") and Furukawa et al., U.S. Patent 6,017,807 (hereinafter "Furukawa"). Applicants respectfully traverse the rejection because Bour specifically teaches away from combination with Furukawa.

Claims 1 and 31 recite "growing in a chamber a III-V nitride compound semiconductor layer at a first temperature . . . cooling said acceptor-doped layer to a second temperature significantly lower than said first temperature during a cool-down process . . . and after said cooling, heating said p-type layer to a third temperature greater than the second temperature and less than 625°C."

In both the present office action and the office action mailed February 24, 2003, the Examiner describes a Bour/Furukawa combination as follows. Furukawa is cited as teaching a thermal anneal to activate the p-type impurities in the device:

Bour et al also does not teach heating said p-type layer to a third temperature greater than the second temperature and less than 625°C.

In a method of forming a P-type GaN compound, note entire reference, Furukawa et al teaches after a p-type gallium nitride compound semiconductor layers formed by chemical vapor deposition, the p-type gallium nitride layers are thermally annealed at more than 400°C and the p-type impurity can be more effectively activated so that p-type gallium nitride compound semiconductor layers which have fewer crystal defects and lower resistivity can be formed (abstract, col 4, ln 5-67 and col 6, ln 35-60). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Bour et al with Furukawa et al annealing at a temperature greater than 400°C to form a semiconductor layer which has fewer defects and lower resistivity.

In response, in the office action response mailed May 22, 2003, Applicants argued that Bour teaches away from combination with Furukawa, because Bour's method is specifically designed to avoid the use of a post-cool-down anneal as described in Furukawa:

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It would not have been obvious to modify Bour's process to add an anneal after cool-down is complete, as taught by Furukawa, because Bour specifically teaches that it is undesirable to complete cool-down prior to performing an anneal. See, for example, column 3, lines 46-50 of Bour which list problems associated with such a post-cool-down anneal including high processing costs, and potential contamination from exposure to the atmosphere accompanying ex-situ processing. Even if the post-cool-down anneal is performed in situ, a person of skill in the art would still expect to encounter high processing times and costs and potential contamination, and would therefore not be motivated to modify Bour's process.

MPEP section 2141 teaches "When applying 35 U.S.C. 103, the following tenets of patent law must be adhered to: . . . The references must be considered as a whole and must suggest the desirability and thus the obviousness of making the combination." Bour's entire teaching is devoted to providing a process that avoids the use of a post-cool-down anneal, and thus cannot possibly suggest the desirability of combining Bour with a reference that uses a post-cool-down anneal. Since Bour specifically teaches away from providing a post-cool-down anneal, Bour cannot be combined with any reference that teaches such an anneal, including Furukawa. (Emphasis in original)

In response, the Examiner states that though Bour teaches a process that does not require a post growth anneal, a post growth anneal would be expected to increase activation yield of a p-type layer, and thus would be a favorable addition to Bour's process:

Applicant's argument that it would not have been obvious to combine Furukawa with Bour has been noted but is not found persuasive. Applicant alleges Bour specifically teaches that it is undesirable to complete cool-down prior to performing an anneal because of high processing times and costs, therefore Bour cannot be combined with Furukawa, which teaches a post cool down anneal. Bour does teach a process that does not require a post growth acceptor activation process, note column 9, lines 1-3, as suggest by applicant, which would reduce processing costs. Bour also recognizes post growth anneals after reactor cool down are common procedure, note column 2, lines 60-65. Furukawa teaches the activation yield of a p-type impurity can be improved by a simple process by annealing at more than 400°C in an inert atmosphere, note column 2, line 60 to column 3, line 10. Bour teaches a process without a post growth anneal to reduce cost and Furukawa teaches a post growth anneal to improve the activation yield of a p-type impurity. Although, the processing cost would increase because of a post growth anneal, a person of ordinary skill in that art at the time of the invention would be motivated to perform a post growth anneal to improve the activation yield. Economics are a concern in all processes; however obtaining a superior product (increased activation yield) is a valid motivation for increasing processing costs. (Emphasis added).

The Examiner's position that a person of skill in the art would be motivated to tolerate problems associated with a post-growth anneal, such as increased processing cost and time, because such an anneal would be expected to improve the performance of the device, is contrary to the teachings of Bour. Bour explains that there is evidence that in III-nitride

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devices, unlike in other III-V devices, passivation of the p-type dopant occurs during growth, not during post-growth cool down:

It has been established in these other Group III-V non-nitride compound semiconductors, that hydrogen is incorporated in the reactor cooldown after growth, rather than during growth. Consequently, ex-situ post-growth anneals have become a common procedure for laser diode processing. In contrast to other, better understood compound semiconductors such as AlGaAs, AlGaInP, and InGaAsP, the mechanism of acceptor passivation has not been established in the nitrides. Theoretical investigations indicate that the acceptors are passivated during growth. On the other hand, as indicated above, in the more common Group III-V arsenides and phosphides, it has already been shown that the passivation occurs during the cooldown after growth.

In a device where passivation occurs during cool-down, a person of skill in the art would expect a post-growth anneal would improve the performance of the device as stated by the Examiner, because the anneal would activated the p-type dopants passivated during cool-down. As taught above in Bour, however, in III-nitride devices, passivation does NOT appear to occur during cool down. Thus, where an in-situ process is performed to active the p-type dopants, as in Bour, a post-growth anneal would not be expected to improve the activation, since no further passivation occurs during cool-down. Accordingly, a person of skill in the art would not be motivated tolerate the disadvantages of a post-growth anneal, discussed above and in Bour, since there is no reason to expect that such a post-growth anneal would improve the device performance.

Applicants respectfully submit that claims 1 and 31 distinguish over Bour, Furukawa, and Koike because there is no motivation to combine Bour and Furukawa as proposed by the Examiner, and Bour in fact teaches away from combination with Furukawa. Claims 1 and 31 are therefore allowable. Claims 3-5 and 12-30 depend from claim 1 and are therefore allowable for at least the same reason. Claims 32-35 and 42-60 depend from claim 31 and are therefore allowable for at least the same reason.

Claims 6, 9, 11, 36, 39, and 41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour, Furukawa, and Koike as applied to claims 1, 3-5, 12-35, and 42-60,

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further in view of Takatani, U.S. Patent No. 6,100,174. Claims 6, 9, and 11 depend from claim 1 and are therefore allowable for at least the reasons stated above for claim 1. Claims 36, 39, and 41 depend from claim 31 and are therefore allowable for at least the reasons stated above for claim 31. Takakani adds nothing to the deficiencies of Bour, Furukawa, and Koike with respect to claims 1 and 31. Accordingly, claims 6, 9, 11, 36, 39, and 41 are allowable over the combination of Bour, Furukawa, Koike, and Takatani.

Claims 10 and 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour, Furukawa, Koike, and Takatani, as applied to claims 6, 9, 11, 36, 39, and 41, and further in view of Peng et al., U.S. Patent No. 5,895,223. Claim 10 depends from claim 9, which depends from claim 1. Claim 10 is therefore allowable for at least the reasons stated above for claim 1. Claim 50 depends from claim 31 and is therefore allowable for at least the reasons stated above for claim 31. Takakani and Peng et al. add nothing to the deficiencies of Bour, Furukawa, and Koike with respect to claims 1 and 31. Accordingly, claims 10 and 50 are allowable over the combination of Bour, Furukawa, Koike, Takatani, and Peng et al.

Claims 13 and 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour, Furukawa, and Koike as applied to claims 1, 3-5, 12-35, and 42-60, further in view of Peng et al. Claim 13 depends from claim 5, which depends from claim 1. Claim 13 is therefore allowable for at least the reasons stated above for claim 1. Claim 43 depends from claim 35, which depends from claim 31. Claim 43 is therefore allowable for at least the reasons stated above for claim 31. Peng et al. adds nothing to the deficiencies of Bour, Furukawa, and Koike with respect to claims 1 and 31. Accordingly, claims 13 and 43 are allowable over the combination of Bour, Furukawa, Koike, and Peng et al.

Claims 7, 8, 37, and 38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour, Furukawa, and Koike as applied to claims 1, 3-5, 12-35, and 42-60, further in view of Nitta et al., U.S. Patent No. 5,789,265. Claims 7 and 8 depend from claim 5, which depends

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from claim 1. Claims 7 and 8 are therefore allowable for at least the reasons stated above for claim 1. Claims 37 and 38 depend from claim 35, which depends from claim 31. Claims 37 and 38 are therefore allowable for at least the reasons stated above for claim 31. Nitta et al. adds nothing to the deficiencies of Bour, Furukawa, and Koike with respect to claims 1 and 31. Accordingly, claims 7, 8, 37, and 38 are allowable over the combination of Bour, Furukawa, Koike, and Nitta et al.

In view of the above arguments, Applicants respectfully request allowance of all pending claims. Should the Examiner have any questions, the Examiner is invited to call the undersigned at (408) 382-0480.

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